



*National Aeronautics and Space
Administration Goddard Earth Science Data
Information and Services Center (GES DISC)*

README Document for GRACE Data Assimilation Version 2 Product

Last Revised July 21, 2017

Goddard Earth Sciences Data and Information Services Center (GES DISC)
<http://disc.gsfc.nasa.gov>
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

README Document for GRACE Data Assimilation Version 2 Product

Prepared By:

Hualan Rui

Name

GES DISC
GSFC Code 610.2

Hiroko Beaudoin

Name

HSL
GSFC Code 617

7/21/2017

Date

Reviewed By:

Carlee Loeser

Reviewer Name

GES DISC
GSFC Code 610.2

2/22/2017

Date

**Goddard Space Flight Center
Greenbelt, Maryland**

Revision History

<i>Revision Date</i>	<i>Changes</i>	<i>Author</i>
01/06/2017	Initial version based on information from README for GRACE-DA-DM Version 1.0	Hualan Rui
01/12/2017	Review and revise	Hiroko Beudoing
03/08/2017	Add DOI	Hualan Rui
06/14/2017	Add the reprocess related information	Hualan Rui
07/21/2017	Update URLs to comply with GES DISC new Web site	Hualan Rui
02/19/2019	Update the URL for NASA GRACE Data Assimilation	Hualan Rui

Contents

.....	1
1.0 Introduction	5
1.1 Dataset Basic characteristics.....	5
1.2 Digital Object Identifier (DOI) and Citation.....	5
1.3 Contact Information.....	6
1.4 What's New?.....	7
1.4.1 What's in GRACE-DA-DM V2.0.....	7
1.4.2 Reprocessed GRACE-DA-DM V2.0.....	7
2.0 Data Organization	7
2.1 File Naming Convention.....	7
2.2 File Format and Structure	8
3.0 Data Contents	8
3.1 Products/Parameters.....	8
4.0 Options for Reading the Data	9
4.1 Utilities	9
4.2 Panoply.....	9
4.3 GrADS	9
5.0 Data Services.....	11
5.1 NASA Earthdata Login System	11
5.2 Data Services.....	12
5.2.1 HTTP	12
5.2.2 EarthData Search	12
5.2.3 OPeNDAP	12
5.2.3 Giovanni	12
6.0 More Information	14
7.0 Acknowledgements.....	14
References	14
Acronyms	15

1.0 Introduction

This document provides basic information for using GRACE Data Assimilation for Drought Monitor Version 2.0 product (abbreviated as GRACE-DA-DM V2.0).

Scientists at NASA's Goddard Space Flight Center generate groundwater and soil moisture drought indicators each week. They are based on terrestrial water storage observations derived from GRACE satellite data and integrated with other observations, using a sophisticated numerical model of land surface water and energy processes. The data product of **Groundwater and Soil Moisture Conditions from GRACE Data Assimilation** contains a set of drought indicators for the North America Drought Monitor.

1.1 Dataset Basic characteristics

The GRACE-DA-DM V2.0 data contain a set of daily drought indicators for the North American Drought Monitor, available only one day (Monday) per week, at 0.125 x 0.125 degree, from April 1, 2002 to present (with 3-6 months latency). The data are in NetCDF format.

Table 1. Basic characteristics of the GRACE-DA-DM data.

Contents	Drought indicators
Input data	GRACE
Land surface models	Catchment Fortuna 2.5 version
Latitude extent	25 ° to 53 °
Longitude extent	-125 ° to -67 °
Spatial resolution	0.125 degree
Temporal interval	7-days
Temporal coverage	2002/04/01 ~ present
Dimension	224 (lat) x 464 (lon)
Grid box center points (lat, lon)	Lower left: (25.0625, -124.9375) Upper right: (52.9375, -67.0625)
Format	NetCDF

1.2 Digital Object Identifier (DOI) and Citation

A Digital Object Identifier or DOI is a unique alphanumeric string used to identify a digital object and provide a permanent link online. DOIs are often used in online publications in citations.

DOI for GRACE-DA-DM V2.0 data product: [10.5067/ASNKR4DD9AMW](https://doi.org/10.5067/ASNKR4DD9AMW)

README Document for GRACE Data Assimilation Version 2 Product

Citation example:

Matthew Rodell and Hiroko Kato Beudoing, NASA/GSFC/HSL (2017), *Groundwater and Soil Moisture Conditions from GRACE Data Assimilation L4 7-days 0.125 x 0.125 degree Version 2.0*, Greenbelt, Maryland, USA: Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed [**Data Access Date**] 10.5067/ASNKR4DD9AMW

Primary Reference

Houborg, R., M. Rodell, B. Li, R. Reichle, and B. Zaitchik, 2012: Drought indicators based on model assimilated GRACE terrestrial water storage observations, *Wat. Resour. Res.*, 48, W07525, doi:10.1029/2011WR011291

1.3 Contact Information

For information about or assistance in using any GES DISC data, please contact the GES DISC Help Desk at:

GES DISC
Code 610.2
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Email: gsfc-help-disc@lists.nasa.gov
301-614-5224 (voice)
301-614-5268 (fax)

For general science questions and comments, please contact:

Matthew Rodell, Ph.D.
Hydrological Sciences Laboratory, Code 617
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Email: Matthew.Rodell@nasa.gov
Phone: 301-286-9143

Or

Hiroko Kato Beudoing, M.S.
Earth System Science Interdisciplinary Center
University of Maryland, College Park
Hydrological Sciences Laboratory, Code 617
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Email: Hiroko.Kato-1@nasa.gov
Phone: 301-286-9143

1.4 What's New?

1.4.1 What's in GRACE-DA-DM V2.0

The GRACE-DA-DM V2.0 data product is based on the Catchment Land Surface Model (CLSM) Fortuna 2.5 version simulation that was created by the Land Information System data assimilation framework. This simulation used the latest gridded GRACE solutions, at 0.5 degree resolution, from the University of Texas at Austin. On the other hand, Version 1.0 was created by the stand alone CLSM (an older version) using the GRACE-Tellus 1 degree data from the Center for Space Research at University of Texas. The GRACE data assimilation (DA) is executed on grid-to-grid basis in Version 2.0 (Kumar et al. 2016), while basin scale average was used in Version 1.0 (Zaitchik et al. 2008). The simulation upgrades includes fixes in the DA and increased bedrock depth by 3 meters to enhance the drought indicator calculations.

1.4.2 Reprocessed GRACE-DA-DM V2.0

The GRACE-DA-DM V2.0 data have been reprocessed (on June 14, 2017), using the GRACE RL05 Mascon solutions version 1 data set from the Center for Space and Research at University of Texas, for the entire period from April 1, 2002 to June 5, 2017. Because the GRACE observation data currently end in December 2016, the GRACE-DA-DM V2.0 data for January 1 to June 5, 2017 were generated without GRACE data and will be reprocessed when their corresponding GRACE data become available. The reprocessed GRACE-DA-DM files can be identified by the metadata of global attributes “input” and “history” in the netCDF files.

2.0 Data Organization

2.1 File Naming Convention

GRACE-DA-DM data files are named in accordance with the following convention:

GRACEDADM_<Model><Grid spacing><Region>_<Temporal spacing>_.A<Date>.<Product version>.nc4

Attribute	Description
GRACEDADM	GRACE Data Assimilation for Drought Monitor
<Model>	“CLSM” for the Catchment Land Surface Model
<Grid spacing>	“0125” for 1/8th degree

README Document for GRACE Data Assimilation Version 2 Product

<Region>	"US" for CONUS region
<Temporal spacing>	"7D" for 7-days
<Date>	<YYYYMMDD>
<Product version>	"020" for Version 2.0

Filename example: GRACEDADM_CLSM0125US_7D.A20020401.020.nc4

2.2 File Format and Structure

The GRACE-DA-DM V2.0 files are in NetCDF format, which is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data, <http://www.unidata.ucar.edu/software/netcdf/docs/>.

3.0 Data Contents

3.1 Products/Parameters

The GRACE-DA-DM V2.0 data product contains three drought indicators, Groundwater Percentile, Root Zone Soil Moisture Percentile, and Surface Soil Moisture Percentile. The drought indicators are of wet or dry conditions, expressed as a percentile, indicating the probability of occurrence within the period of record from 1948 to 2012. These GRACE-assimilated drought indicators, with improved spatial and temporal resolutions, should provide a more comprehensive and objective identification of drought conditions. More information is available at <https://nasagrace.unl.edu/>.

Table 2. Variables in the GRACE-DA-DM Data Product

Short Name	Description	Unit
gws_inst	Groundwater Percentile	%
rtzsm_inst	Root Zone Soil Moisture Percentile	%
s fsm_inst	Surface Soil Moisture Percentile	%

4.0 Options for Reading the Data

4.1 Utilities

GRACE-DA-DM data are archived in self-describing and machine-independent NetCDF format. <http://www.unidata.ucar.edu/software/netcdf/software.html>, a Unidata page, provides a list of software for manipulating or displaying NetCDF Data.

4.2 Panoply

Panoply, <http://www.giss.nasa.gov/tools/panoply/>, is a cross-platform application that plots geo-referenced and other arrays from NetCDF, HDF, GRIB, and other data sets. The [HowTo](#) of NASA GES DISC provides a recipe for [Quick View Data with Panoply](#).

4.3 GrADS

The Grid Analysis and Display System (GrADS) is an interactive desktop tool for easy access, manipulation, and visualization of earth science data. GrADS supports several data formats, such as binary, NetCDF, HDF, and GRIB. The documentation and software for GrADS can be found at: <http://cola.gmu.edu/grads/grads.php>.

Each individual GRACE-DA-DM NetCDF file can be opened by GrADS `sdfopen` directly without a data descriptor file (aka ctl file). After calling `sdfopen`, GrADS commands, such as “`q dims`”, “`q file`”, “`d [variable_name]`”, etc. can be used to query file information, read and display the data. Below is an example showing how to `sdfopen` a GRACE-DA-DM NetCDF file and query for the dimensions and variables of the file.

```
hrui@hydro1: $ grads
      Welcome to the OpenGrADS Bundle Distribution
-----
For additional information enter "grads -h".
Starting "/opt/grads-2.1.a2.oga.1/Linux/Versions/2.1.a2.oga.1/x86_64/grads " ...
Grid Analysis and Display System (GrADS) Version 2.1.a2.oga.1
Copyright (c) 1988-2013 by the Institute for Global Environment and Society (IGES)
GrADS comes with ABSOLUTELY NO WARRANTY
See file COPYRIGHT for more information
```

README Document for GRACE Data Assimilation Version 2 Product

```
Config: v2.1.a2.oga.1 little-endian readline grib2 netcdf hdf4-sds hdf5 opendap-
grids,stn athena geotiff shapefile cairo
Issue 'q config' command for more detailed configuration information
Loading User Defined Extensions table </opt/grads-
2.1.a2.oga.1/Linux/Versions/2.1.a2.oga.1/x86_64/gex/udxt> ... ok.
Landscape mode? ('n' for portrait):
GX Package Initialization: Size = 11 8.5
ga-> sdfopen GRACEDADM_CLSM0125US_7D.A20020401.020.nc4
Scanning self-describing file: GRACEDADM_CLSM0125US_7D.A20020401.020.nc4
SDF file GRACEDADM_CLSM0125US_7D.A20020401.020.nc4 is open as file 1
LON set to -124.938 -67.0625
LAT set to 25.0625 52.9375
LEV set to 0 0
Time values set: 2002:4:1:0 2002:4:1:0
E set to 1 1
ga-> q dims
Default file number is: 1
X is varying Lon = -124.938 to -67.0625 X = 1 to 464
Y is varying Lat = 25.0625 to 52.9375 Y = 1 to 224
Z is fixed Lev = 0 Z = 1
T is fixed Time = 00Z01APR2002 T = 1
E is fixed Ens = 1 E = 1
ga-> q file
File 1 : GRACE Data Assimilation Drought Indicator
Descriptor: /var/tmp/hrui/GRACEDADM_CLSM0125US_7D.A20020401.020.nc4
Binary: /var/tmp/hrui/GRACEDADM_CLSM0125US_7D.A20020401.020.nc4
Type = Gridded
Xsize = 464 Ysize = 224 Zsize = 1 Tsize = 1 Esize = 1
Number of Variables = 3
  gws_inst 0 t,y,x Groundwater storage percentile
  rtzsm_inst 0 t,y,x Root zone soil moisture percentile
  sfsm_inst 0 t,y,x Surface soil moisture percentile
ga->
```

By using GrADS command [xdfopen](#) with a GrADS descriptor file, multiple GRACED-DA-DM NetCDF files can be opened, therefore, temporally aggregated visualization and data analysis can be done by GrADS. Below is a GrADS sample descriptor file for the GRACE-DA-DM files..

GRACEDADM_CLSM0125US_7D.2.0.xdf, a sample data descriptor file

```
DSET GRACEDADM_CLSM0125US_7D.A%y4%m2%d2.020.nc4
UNDEF -999.
OPTIONS template
TDEF time 1 LINEAR 01APR2002 7dy
```

An example for using xdfopen to open GRACEDADM_CLSM0125US_7D.2.0.xdf

```
ga-> xdfopen GRACEDADM_CLSM0125US_7D.2.0.xdf
Scanning Descriptor File: GRACEDADM_CLSM0125US_7D.2.0.xdf
SDF file /var/tmp/hrui/GRACEDADM_CLSM0125US_7D.A%y4%m2%d2.020.nc4 is
open as file 1
LON set to -124.938 -67.0625
LAT set to 25.0625 52.9375
LEV set to 0 0
Time values set: 2002:4:1:0 2002:4:1:0
E set to 1 1
ga-> q file
File 1 : GRACE Data Assimilation Drought Indicator
Descriptor: GRACEDADM_CLSM0125US_7D.2.0.xdf
Binary: /var/tmp/hrui/GRACEDADM_CLSM0125US_7D.A%y4%m2%d2.020.nc4
Type = Gridded
Xsize = 464 Ysize = 224 Zsize = 1 Tsize = 1 Esize = 1
Number of Variables = 3
gws_inst 0 t,y,x Groundwater storage percentile
rtzsm_inst 0 t,y,x Root zone soil moisture percentile
sfsm_inst 0 t,y,x Surface soil moisture percentile
ga->
```

5.0 Data Services

5.1 NASA Earthdata Login System

Starting August 1st, 2016, access to GES DISC data requires all users to be registered with the Earthdata Login system. Data continue to be free of charge and accessible via HTTP. Access to data via FTP will no longer be available on or after October 3rd, 2016. Detailed instructions on how to register and receive authorization to access GES DISC data are provided at
<https://disc.sci.gsfc.nasa.gov/data-access>.

GES DISC users who deploy scripting methods to list and download data in bulk via anonymous FTP are advised to review the [How to Download Data Files from HTTP Service with wget](#) recipe that provides examples of GNU wget commands for listing and downloading data via HTTP.

If you need assistance or wish to report a problem:

README Document for GRACE Data Assimilation Version 2 Product

Email: gsfc-help-disc@lists.nasa.gov

Voice: 301-614-5224

Fax: 301-614-5268

Address:

Goddard Earth Sciences Data and Information Services Center
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

5.2 Data Services

[GRACE-DA-DM V2.0 data product landing page](#) provides product summary, data citation, documentation, and data access.

5.2.1 HTTP

Access the online archive data via HTTP:

https://hydro1.gesdisc.eosdis.nasa.gov/data/GRACEDADM_CLSM0125US_7D.2.0

5.2.2 EarthData Search

Use the Earthdata Search Client (EDSC) to find and retrieve data sets across multiple data centers:

https://search.earthdata.nasa.gov/search?q=GRACEDADM_CLSM0125US_7D

5.2.3 OPeNDAP

Access the data via the OPeNDAP protocol for parameter and spatial subsetting:

<https://hydro1.gesdisc.eosdis.nasa.gov/opendap/hyrax/GRACEDA/>

5.2.3 Giovanni

The GES-DISC Interactive Online Visualization AND aNalysis Interface (Giovanni) is a web-based tool that allows users to interactively visualize and analyze data:

https://giovanni.gsfc.nasa.gov/giovanni/#dataKeyword=GRACEDADM_CLSM0125US_7D

The two sample images below are generated by NASA [Giovanni](#).

README Document for GRACE Data Assimilation Version 2 Product

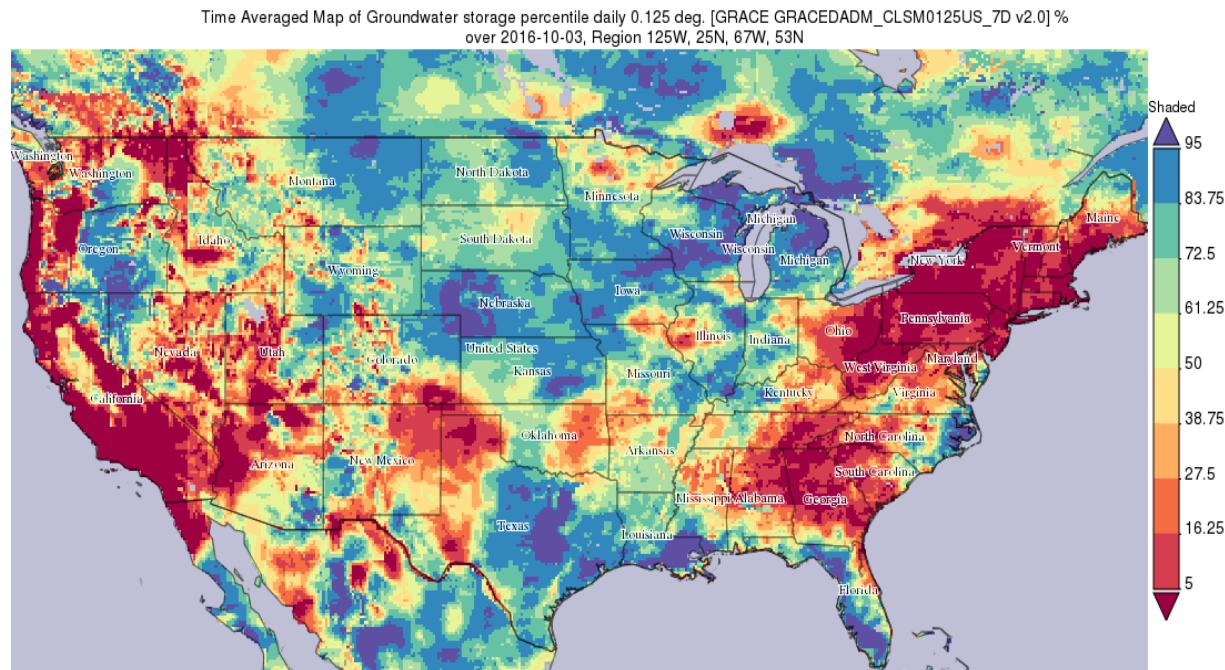


Figure 1. Groundwater storage percentile map for October 3, 2016 from GRACE-DA-DM 0.125 x 0.125 degree daily data.

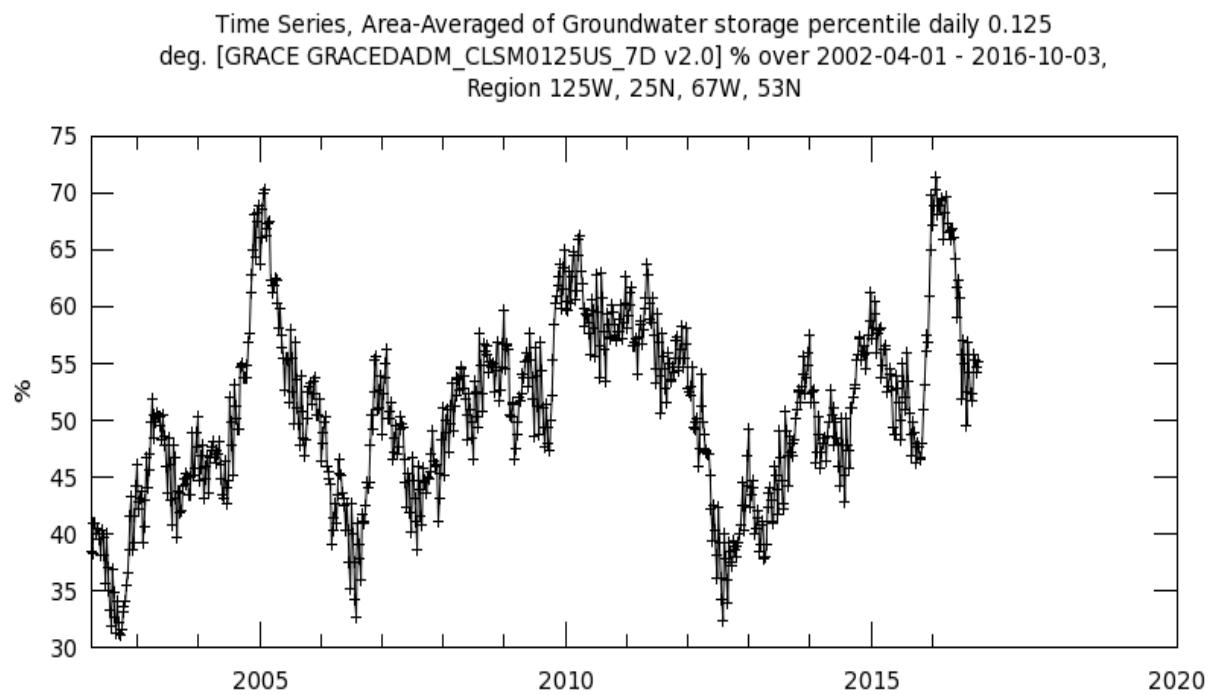


Figure 2. Time series of Groundwater storage percentile from GRACE-DA-DM 0.125 x 0.125 degree daily data, averaged over North America.

6.0 More Information

Groundwater and Soil Moisture Conditions from GRACE Data Assimilation Site:

<https://nasagrace.unl.edu/>

Land Data Assimilation System (LDAS) Project: <http://ldas.gsfc.nasa.gov/>

7.0 Acknowledgements

The GRACE-DA-DM V2.0 data is produced by NASA GSFC Hydrological Sciences Laboratory (HSL).

References

Houborg, R., M. Rodell, B. Li, R. Reichle, and B. Zaitchik, 2012: Drought indicators based on model assimilated GRACE terrestrial water storage observations, *Wat. Resour. Res.*, 48, W07525, doi:10.1029/2011WR011291

Kumar, S. V., B. F. Zaitchik, C. D. Peters-Lidard, et al., 2016: Assimilation of gridded GRACE terrestrial water storage estimates in the North American Land Data Assimilation System, *J. Hydrometeor.*, 17 (7), 1951-1972, doi:10.1175/jhm-d-15-0157.1

Zaitchik, B.F., M. Rodell, and R.H. Reichle, 2008: Assimilation of GRACE terrestrial water storage data into a land surface model: results for the Mississippi River Basin, *J. Hydrometeor.*, 9 (3), 535-548, doi:10.1175/2007JHM951.1

Acronyms

The following acronyms and abbreviations are used in this document.

GDS	GrADS Data Server
GES DISC	Goddard Earth Sciences Data and Information Services Center
Giovanni	GES-DISC Interactive On-line Visualization and Analysis Infrastructure
GRACE	Gravity Recovery and Climate Experiment
GRADS	Grid Analysis and Display System
GRIB	GRIdded Binary
HDF	Hierarchical Data Format
HSL	Hydrological Sciences Laboratory
LIS	Land Information System
LSM	Land Surface Model
Mirador	Fast interface for searching Earth science data at NASA GES DISC
NASA	National Aeronautics and Space Administration
netCDF	network Common Data Form